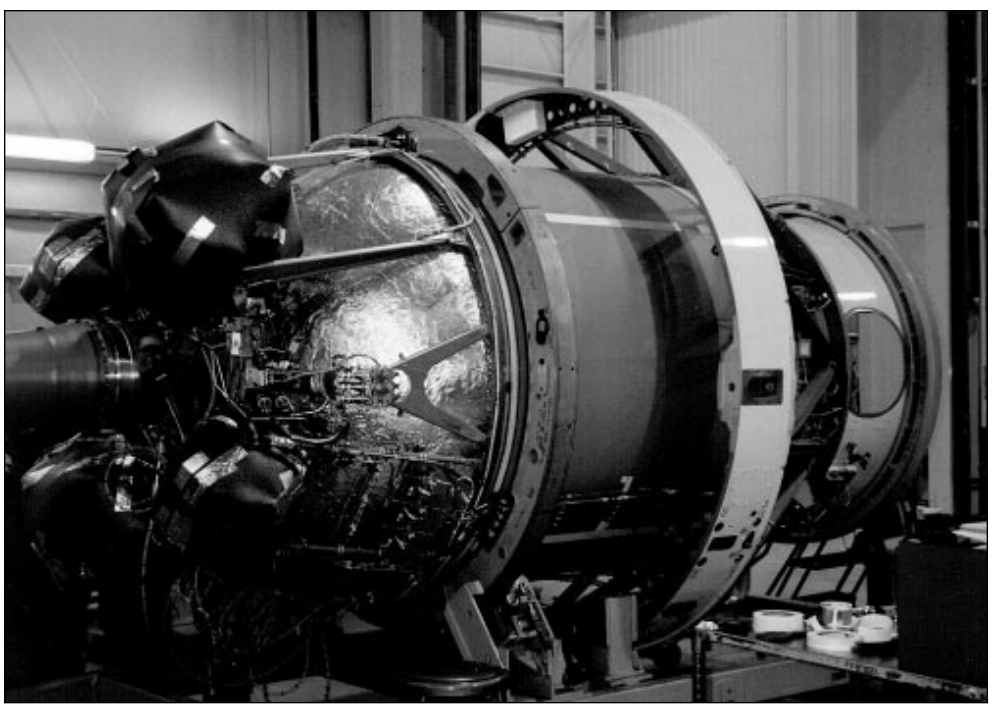
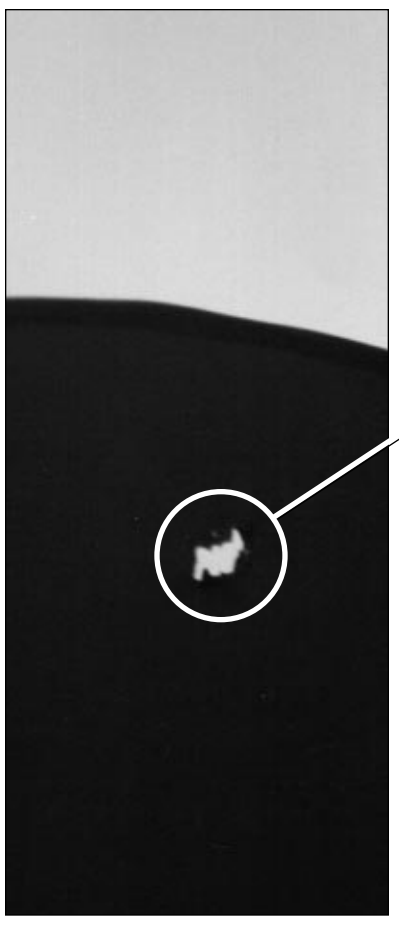


Top: From left, Mike Brennan and Julie Roberts-Pate of Center Operations' Support Operations Division examine the 600-pound Delta propellant tank and an attached sphere that was recently delivered to JSC. The tank and sphere returned to Earth in two different farmers' fields in Texas. The major piece left of the rocket was the stainless steel shell. Right: A Delta propellant tank before launch and reentry.

JSC Photo 97-03302 by Steve Candler, Delta tank photo by Nick Johnson



Top: Before servicing the Hubble Space Telescope, scientists had no idea there was a small tear in the telescope's high gain antenna caused by orbital debris. Despite the damage, the antenna continues to function normally. Right: Astronauts onboard *Discovery* during STS-70 capture evidence that orbital debris can be hazardous to the space shuttle. While orbital debris continues to increase NASA in conjunction with other nations is working to reduce the risk to space travelers. In addition NASA, the Department of Defense and the department of Transportation will present to industry the NASA safety standard for debris management for all NASA spacecraft, which DOD is assessing for its activities and NASA is proposing to be the initial basis for a standard U.S. practice.

NASA Photos STS061-66-016, STS082-310-017 and STS070-309-026

Success Story

JSC scientists influence international change to protect low Earth orbit

Since the early 1980s JSC scientists have devoted their skills to learning about orbital debris and how to protect space travelers. Their efforts are paying off.

JSC scientists—in cooperation with their colleagues around the world—have made great strides in helping curb the growth of debris that circles the Earth. Today there are about 4.6 million pounds of debris in low Earth orbit.

"The situation in terms of the environment is such that it is worse than it was in 1988, but we have made very significant progress in efforts to manage the environment for the future," said Joe Loftus, assistant director for Engineering, Space and Life Sciences Directorate. "Every launching nation has made modifications to the design and operation of its upper stages simply because they recognize that it is in their best interests to do so.

"I think that in terms of environmental management, this is a success story. There will always be a debris threat, but I think the efforts we are engaged in are such that we can probably keep the environment from getting worse than it is. In terms of risks in space operations, this is well into the same range of risks as the other risks we face," Loftus said.

Orbital debris has become an important concern for space travelers, since even a tiny paint flake can cause damage because of its orbiting velocity.

"Orbital debris is anything in Earth orbit that is not a functional spacecraft or an object that cannot perform a useful purpose," said Nick Johnson, JSC's senior scientist on orbital debris.

More than 9,500 large objects are currently being tracked by the Space Surveillance Network at the U.S. Space Command in Colorado Springs. In 39 years of space travel, more than 24,000 pieces of orbital debris have been cataloged. The JSC orbital debris team has conducted experiments during missions to fine-tune equipment, so that measurements and tracking are acurate.

"The issue in low-Earth orbit is the very high velocities and therefore the very large energy exchange when there is an impact," Loftus said. "The spatial density (number of objects per cubic mile) of things in low-Earth orbit is the highest of anywhere in space."

With so much debris, the team is an integral part of missions and International Space Station design teams.

During STS-82, the team worked closely with the Space Surveillance Network and Mission Operations to evaluate special debris hazards. Precise calculations can be made only 24 hours in advance due to the dynamics of debris. Flight Director Brian Austin elected to maneuver *Discovery* away from a possible collision with a piece of a Pegasus upper stage that exploded in orbit.

"The orbital debris threat is different in different directions because of the conjunction of orbits between the debris and the shuttle," Johnson said. "Some portions of the orbiter are more vulnerable than others. So we like to fly upside down with the engines into the direction we are flying. Before the flight, we run models of the entire mission profile to know exactly where the shuttle is pointed during the mission. We protect the shuttle from the big things by simply doing avoidance maneuvers."

Moving from shuttle missions to docking with the Mir Space Station, and building the International Space Station have challenged the team to develop better protection methods.

"When we laid down the shuttle design in the early 70s, we designed to the meteoroid environment as we had for all of our previous spacecraft," Loftus said. "We have lived with the orbital debris environment by controlling the attitude timeline of the missions. When we get into the assembly of the station as in the case of the Mir missions we can no longer control this threat in that manner. So a team has been working to make the orbiter more robust for these missions."

Johnson said the team expects to learn much more about orbital debris as it inspects the largest known piece of space debris to reenter the atmosphere and land on Earth. The debris was recently delivered to JSC.

The 600-pound Delta propellant tank and an attached sphere returned to Earth in two different farmers' fields in Texas. The major piece left of the rocket was the stainless steel shell. Aluminum bands around the rocket and the engines had melted during reentry, but the rivets and bolts that held them in place were intact. The 67-pound titanium sphere was detached from the rocket but otherwise intact.

The debris was returned to JSC because scientists here are considered the international experts in orbital debris and hypervelocity impact, having continually studied the subject.

"In the past the DOD has questioned the significance of the orbital debris hazard," Johnson said. "But, recently most of the DOD is coming to believing that what we say is in accurate."

Orbital debris is not just a concern for NASA. In conjunction with other nations, NASA is a leader in the working group helping to reduce the amount of orbital debris in space.

"We have what's called the Interagency Space Debris Coordination Working Group and every launching nation with the exception of Israel is a member," Loftus said. "We meet generally about twice a year. We coordinate observation campaigns, modeling studies, explosive tests, design and operations practices. Within the United States we have an interagency working group, predominantly NASA and DOD, but also Transportation, FCC, State and Commerce, and the intelligence community."

At an upcoming workshop, NASA, DOD and DOT will present to industry the NASA safety standard for debris management for all NASA spacecraft, which the DOD is assessing for its activities and NASA is proposing the initial basis for a standard U.S. practice.

"The purpose of the workshop is to get industry views as to what we are doing," said Loftus. "My sense is that they will respond positively because this is a very different environment than most environmental management problems. The problem with trying to control pollution in terrestrial settings is that we (here) may create atmospheric pollution, but the people who get the benefit of it are in Ohio. In space, everybody is downstream from themselves. Because everything moves, it's in everybody's best interest to minimize debris."

While the threat is still there, scientists are making progress to reduce and protect space travelers from orbital debris.

"This is a success story," Loftus said. "The people who are using this environment are accepting the costs of trying to protect it for future operations. And it's all been done on a voluntary basis. I think that's a unique thing in environmental history." ❑